INDOOR AIR QUALITY ASSESSMENT

Lynnhurst Elementary School
Walnut Street
Saugus, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
Emergency Response/Indoor Air Quality Program
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Background/Introduction

At the request of a parent, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA) provided assistance and consultation regarding indoor air quality concerns at the Lynnhurst Elementary School in Saugus, Massachusetts.

On November 13, 2002, a visit was made to this school by Cory Holmes, an Environmental Analyst in the Emergency Response/Indoor Air Quality (ER/IAQ), BEHA, to conduct an indoor air quality assessment. Deborah Rosati, Director of the Saugus Health Department; Kevin Nigro, Director of Inspectional Service; Michael Tanen, School Principal and Janet Mulready, School Custodian, accompanied Mr. Holmes for portions of the assessment.

The school is a one-story brick building constructed in 1965. Two classrooms were reportedly added approximately two years after the school opened. The school contains general classrooms, cafeteria/gymnasium, library, health suite and main office.

Methods

Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551.

Results

This school houses grades K-5 and has a student population of 263 and a staff of approximately 20. Tests were taken during normal operations at the school and results appear in Tables 1-3.

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were elevated above 800 parts per million of air (ppm) in all areas surveyed, indicating inadequate ventilation. It is also important to note that a number of classrooms had elevated carbon dioxide levels with open windows and/or little to no occupancy further indicating a lack of air exchange (see Tables).

Fresh air in classrooms is supplied by a unit ventilator (univent) system (see Picture 1). Univents draw air from outdoors through a fresh air intake located on the exterior walls of the building (see Picture 2) and return air through an air intake located at the base of each unit (see Figure 1). Fresh and return air are mixed, filtered, heated and provided to classrooms through a fresh air diffuser located in the top of the unit. Univents appear to be original equipment. The majority of univents were not operating during the assessment due to mechanical problems with the thermostats/pneumatic system. Mr. Nigro reported that this problem was in the process of being addressed by an HVAC engineering firm who had a representative present in the building during the assessment. Obstructions to airflow, such as papers and books stored on univents and items in front of univent returns were seen in a number of classrooms (see Picture 3). In order for univents to provide fresh air as designed, intakes must remain free of obstructions. Importantly, these units must remain "on" and allowed to operate while these rooms are occupied.

Exhaust ventilation in classrooms consists of grilles located in the ceiling of coat closets (see Picture 4), which are powered by rooftop motors. Air is drawn into the coat closet from the classroom via undercut closet doors (see Picture 5). This exhaust system was either not functioning or drawing weakly in a number of the areas surveyed, indicating the motors were deactivated or non-functional. BEHA staff examined exhaust motors on the roof and found several not operating. In addition, the location of these closet vents allows them to be easily blocked by stored materials. Further decreasing airflow was the accumulation of dirt and dust build-up on exhaust vents. As with the univents, in order to function properly, exhaust vents must be activated and remain free of obstructions.

In order to have proper ventilation with a mechanical supply and exhaust system, these systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. According to school department officials, the date of the last balancing of these systems was not available at the time of the assessment. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994).

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week based on a time weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information on carbon dioxide see Appendix I.

Temperature readings were within a range of 67 ^{o} F to 76 ^{o} F, which were below the BEHA comfort guidelines in some areas. The BEHA recommends that indoor air temperatures be maintained in a range between 70 ^{o} F to 78 ^{o} F in order to provide for the comfort of building occupants. A number of temperature control/comfort complaints were expressed throughout the building, primarily heat issues. These complaints may be attributed to the deactivation of univents. The univents are designed to mix fresh outdoor air with air from inside the room. Without the draw of outdoor air, return air is not tempered and is repeatedly heated, leading to high temperatures. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply. However, it is difficult to control temperature and maintain comfort without operating the ventilation equipment as designed (e.g., univents deactivated, exhaust vents obstructed/inoperable).

The relative humidity in the building was within the BEHA recommended comfort range in all areas surveyed. Relative humidity measurements ranged from 42 to 48 percent. The BEHA recommends that indoor air relative humidity is comfortable in a range of 40 to 60 percent. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

Caulking around windows was missing/damaged in many areas (see Picture 6). In some areas attempts were made to reseal windows (see Picture 7). Some of the panes were loose and drafts were evident in many areas. Missing caulking and/or loose fitting window panes can make it difficult to control temperature and allow a means for water penetration into the building, leading to comfort complaints and/or water damage and subsequent microbial growth.

Efflorescence (i.e., mineral deposits) was observed in the cafeteria on brick walls (see Picture 8). Efflorescence is a characteristic sign of water damage to building materials such as brick or plaster, but it is not mold growth. As moisture penetrates and works its way through mortar around brick, water-soluble compounds in bricks and mortar dissolve, creating a solution. As the solution moves to the surface of the brick or mortar, water evaporates, leaving behind white, powdery mineral deposits. This condition indicates that water from the exterior has penetrated into the building. In this case the most likely source of water penetration is the roof/skylight junction. School and town officials have contacted a number of roofing contractors and have been working to remediate the leak.

Pooling water was observed in a number of areas on the roof (see Picture 9). The freezing and thawing of water during winter months can lead to roof leaks and subsequent water penetration into the interior of the building. Pooling water can also become stagnant, which can lead to mold and bacterial growth, which can be introduced into the building by rooftop ventilation equipment. In addition, stagnant pools of water can serve as a breeding ground for mosquitoes.

Spaces between the sink countertop and backsplash were noted in most of the classrooms. Improper drainage or sink overflow could lead to water penetration of countertop wood, the cabinet interior and behind cabinets. Like other porous materials, if these materials become wet repeatedly they can provide a medium for mold growth.

An open utility hole was observed in a wall/ceiling panel on the exterior of the building (see Picture 10). Breaches in the building envelope can provide a means for water/water vapor penetration into the building. Repeated water damage to porous building materials (e.g., wallboard, ceiling tiles, carpeting) can result in microbial growth. The American Conference of Governmental Industrial Hygienists (ACGIH) recommends that porous building materials be dried with fans and heating within 24 hours of becoming wet (ACGIH, 1989). If not dried within this time frame, mold growth may occur. Once mold has colonized porous materials, they are difficult to clean and should be removed.

Other Concerns

Also of note was the amount of materials stored inside classrooms. In classrooms throughout the school, items were observed on windowsills, tabletops, counters, bookcases and desks. The large number of items stored in classrooms provide a source for dusts to accumulate. These items, (e.g., papers, folders, boxes, etc.) make it difficult for custodial staff to clean. Dust can be irritating to eyes, nose and respiratory tract. Items should be relocated and/or be cleaned periodically to avoid excessive dust build up. A univent was opened to inspect the interior and had accumulated dust and cobwebs. The operation of univent fan motors can aerosolize dust particles. In addition, these materials can accumulate on flat surfaces (e.g., desktops, shelving and carpets) in occupied areas and subsequently be re-aerosolized causing further irritation.

Cleaning products were found on countertops and beneath sinks in a number of classrooms (see Picture 11). Cleaning products contain chemicals, which can be irritating to the eyes, nose and throat and should be stored properly and kept out of reach of students.

A few classrooms contained assorted animals in cages. Porous materials (i.e., wood shavings) can absorb animal wastes and can be a reservoir for mold and bacterial growth. Animal dander, fur and wastes can all be sources of respiratory irritants.

Animals and animal cages should be cleaned regularly to avoid the aerosolization of allergenic materials and/or odors (NIOSH, 1998).

Several classrooms contained dry erase boards and dry erase markers. Materials such as dry erase markers and dry erase board cleaners may contain volatile organic compounds (VOCs), (e.g., methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve) (Sanford, 1999), which can be irritating to the eyes, nose and throat.

Conclusions/Recommendations

The conditions related to indoor air quality problems at the Lynnhurst Elementary School raise a number of issues. The combination of the general building conditions, maintenance, condition of HVAC equipment and the limited availability of replacement parts, if considered individually, present conditions that could degrade indoor air quality. When combined, these conditions can serve to further negatively affect indoor air quality. Some of these conditions can be remedied by actions of building occupants. Other remediation efforts will require alteration to the building structure and equipment. For these reasons a two-phase approach is required, consisting of **short-term** measures to improve air quality and **long-term** measures that will require planning and resources to adequately address the overall indoor air quality concerns.

The following **short-term** measures should be considered for implementation:

1. Continue to work with HVAC engineer to repair the ventilation control system. Have engineer survey classrooms for univent function to ascertain if an adequate air supply exists for each room. Consider having univent fresh air control dampers calibrated school-wide.

2. Inspect rooftop exhaust motors and belts for proper function, repair and replace as necessary.
3. Remove all blockages from univents and exhaust vents. Clean out interiors of univents regularly (e.g. with filter changes).
4. To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy independent of classroom thermostat control.
5. Once both the fresh air supply and exhaust ventilation are functioning, the ventilation system should be balanced.
6. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).
7. Continue working with roofing contractor to eliminate leaks in the gym/cafeteria. Replace any water-stained ceiling tiles and building materials. Examine the area above and around these areas for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial.
8. Seal areas around sinks to prevent water-damage to the interior of cabinets and adjacent wallboard. Inspect wallboard for water-damage and mold/mildew growth, repair/replace as necessary. Disinfect areas of microbial growth with an appropriate antimicrobial as needed. Consider replacing with one-piece, molded countertops as shown in Picture 12.

9. Replace wall panel or permanently seal open utility hole shown in Picture 10.
10. Store cleaning products properly and out of reach of students.
11. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.

The following **long-term measures** should be considered:

1. Based on the age, physical deterioration and availability of parts of the HVAC system, the BEHA strongly recommends that an HVAC engineering firm fully evaluate the ventilation system and its control system (e.g. pneumatic controls, air intake louvers, thermostats).
2. Consider consulting a building engineer about possible options to eliminate water pooling on roof.
3. Repair/replace missing or damaged window caulking building-wide to prevent water penetration through window frames. Examine the feasibility of full window replacement.

References

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Picture 1

Typical Classroom Univent

Picture 2

Univent Outside Air Intake

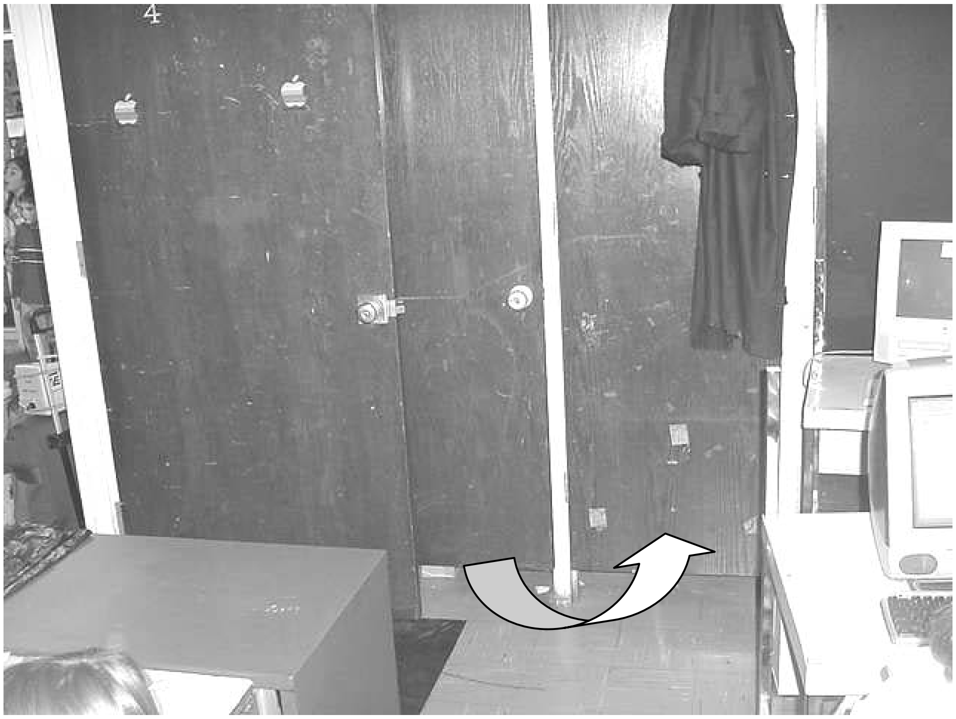
Picture 3

Univent Return Vent (bottom) Obstructed by Various Items

Picture 4

Classroom Exhaust Vent in Top of Coat Closet

Picture 5



Undercut Coat Closet Doors

Picture 6

Exterior Shot of Window Caulking, (Pen Inserted by BEHA staff to Show Scale)

Picture 7

Window Caulking Interior of Classroom, Note Incomplete/Irregular Pattern

Picture 8

Water Damage/Efflorescence on Wall Brick along Skylight Junction

Picture 9

Pooling Water on Roof, Note the Majority of the Wing has Pooling Water

Picture 10

Utility Hole in Side Panel of Building

Picture 11

Spray Cleaning Products beneath Classroom Sink

Picture 12

One-Piece Molded Countertop

TABLE 1

Saugus, Lynnhurst Elementary School **Date: November 13, 2002**

Location	CO_2 *ppm	Temp °F	RH%	Occupants in room	Windows openable	Ventilation		Remarks
						Intake	Exhaust	
Background	501	51	53					Cold, moderate to heavy rainfall, light breeze
Room 1	1,069	67	47	28	Y	Y	Y	Window and door open, UV off, 2 ceiling fans, spaces splashboard/sink, spray paints, closet exhaust and off
Room 2	1,819	71	49	29	Y	Y	Y	UV and exhaust off, cleaning products under sink Spaces – sink
Room4	882	69	42	20	Yes	Y	Y	22 computers UV on, exhaust off, door open
Room 3	963	71	42	2	Y	Y	Y	Window open, occupants gone 20 minutes 22 computers
Cafeteria/gym	992	70	44	110	N	Y	Y	Exhaust blocked, chronic leaks around skylights/roof junction, efflorescence
Room 5	1,907	73	48	20	Y	Y	Y	Cleaning product, spaces – sink/counter wet UV on, exhaust weak
Room 6	2,200	73	48	20	Y	Y	Y	UV off

*** ppm = parts per million parts of air**
CT = ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 2

Saugus, Lynnhurst Elementary School **Date: November 13, 2002**

Location	CO_2 *ppm	Temp °F	RH%	Occupants in room	Windows openable	Ventilation		Remarks
						Intake	Exhaust	
Room 7	2,232	73	48	20	Y	Y	Y	Cleaning product on counter top window and door open
Room 8	1,470	74	46	23	Y	Y	Y	UV on, spray cleaning product under sink
Room 9	2,085	73	48	20	Y	Y	Y	UV off, door open 10 plus water damaged CT (old)
Room 11	2,512	74	48	22	Y	Y	Y	UV off, door open Heat complaints
Room 12	2,021	74	47	15	Y	Y	Y	UV and exhaust off, door open Spray cleaning product under sink
Room 10	2,174	76	45	0	Y	Y	Y	Cobweb and dust buildup in UV cabinet, door open
Library	1,262	74	43	2	N	Y	N	Ceiling vent no draw
Health Room	1,206	75	43	0	N	Y	N	Bathroom exhaust – no draw
Main Office	1,184	74	43	3	N	Y	N	Ceiling vent – no draw

*** ppm = parts per million parts of air**
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TABLE 3

Saugus, Lynnhurst Elementary School **Date: November 13, 2002**

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